National Aeronautics and
Space Administration

Glenn Research Center
Cleveland, Ohio

Space Acceleration Measurement System (SAMS) on STS–107

STS–107 SAMS System

The primary means for scientists to learn more about the microgravity conditions affecting their research is from the SAMS. The SAMS system is produced by the Microgravity Environment Program (MEP) at the NASA Glenn Research Center. The MEP produces a variety of microgravity measurement hardware for on-orbit spacecraft (the International Space Station (ISS) and the space shuttle) and ground-based flights (drop towers, parabolic aircraft, and sounding rockets). Together the various SAMS (SAMS, SAMS–FF (free flyer), and SAMS–II) have supported 22 shuttle missions, the Mir Space Station, and provides ongoing long-term support on the ISS.

The version of the hardware flying on STS–107 is SAMS–FF. This is the second space shuttle flight for the SAMS–FF system, which is a third-generation SAMS system. SAMS–FF uses one-half the power and is only one-third the weight of the original SAMS hardware. It is constructed using industrial-grade components to provide a flexible, modular system that is easily customized for each particular mission. SAMS–FF takes advantage of its flexibility by supporting various ground-based experiments such as sounding rockets between shuttle flights. Characterizing these more quiescent ballistic flights has led to ongoing design improvements. The free flyer name is derived from these ongoing investigations on unmanned vehicles.

The SAMS–FF triaxial sensor head is a small and compact acceleration sensor designed to measure the general vibratory environment. The accelerometers protrude from the enclosure, which contains the microprocessor-based data acquisition system.

The PC/104-based CDU is a small embedded computer system that interfaces between the external sensors and the SPACEHAB module.

The SAMS–FF system consists of a control and data acquisition unit (CDU), three remote acceleration sensor heads, and a fiber-optic gyroscope. The CDU is similar to a desktop computer, except that it is packaged to meet the rigors of spaceflight. It is used to control the operation from the ground and process data from the sensors through a telemetry data stream, which can be seen on NASA computers on the ground. This allows experimenters to view the data collected during the mission so they can correlate their science results with the SAMS data in real time.

Three accelerometers are precisely mounted at right angles to form a triaxial sensor head (TSH). This allows the sensor head to detect vibrations in three different directions of movement: what would be on Earth up and down, forward and backward, and side-to-side. Since there is no up or down in microgravity, the planes are referred to as X, Y, and Z axes. The data is processed to provide the resultant vector of the magnitude and direction, as well as the frequency content, of various time intervals.

The TSH is a microcontroller-based data acquisition system capable of measuring the microgravity accelerations of the shuttle. Sensitive inertial grade accelerometers are used to resolve the very low forces experienced during quiet periods and have the dynamic range to measure the larger vibration disturbances. The output of the accelerometers is digitized using 24-bit sigma-delta analog-to-digital converters to provide a precise readout of the acceleration level. The bandwidth of the TSH is selectable, and the SAMS team commands the operation depending on the desired frequency range of interest. The data and data rate are controlled through an RS–422 serial port connected to the CDU.

A new sensor flown on STS–107 is an inertial grade fiber-optic gyroscope (FOG). To fully capture the motion of the vehicle, not only are the forces examined in three linear or straight directions, but also the rotation of the vehicle is measured to understand the torque forces. Mechanical gyroscopes are used to measure the rotation of the shuttle so it can be controlled. The FOG has no moving parts and is used as an electronic means to precisely measure the roll, pitch, and yaw of the shuttle. It does this by comparing the speed of beams of light traveling in opposite directions around a very long coil of fiber. If there is no rotation, the beams recombine at exactly the same time. However, if the coil is rotated in a particular direction, travel takes longer in the opposite direction before it exits the the coil. This difference is detected by sensitive electronic circuits to determine the rate at which the rotation occurs. Lower grade versions of these gyroscopes are also used in automobiles, combined with GPS data for electronic positioning displays during travel. This is the first shuttle flight for this state-of-the-art device as part of the SAMS system.

The fibersense FOG (right), shown here with a TSH (center), and FOG electronics enclosure (left), precisely measures angular velocity rates without any moving parts.

Orbital Acceleration Research Experiment (OARE)

In addition to SAMS, which is mounted inside the SPACEHAB and shuttle middeck areas to measure the vibratory accelerations onboard the STS–107 mission, the OARE accelerometer system is used to characterize (measure) the quasi-steady environment. OARE is designed to measure very low frequency microgravity accelerations caused by upper atmospheric drag (as the shuttle passes through the upper atmosphere), rigid body inertial rotations, gravity-gradient effects, shuttle's mass expulsion and crew activities. OARE acceleration data complements that of SAMS by providing the scientists a more thorough understanding of the various accelerations that can affect the experiments onboard the shuttle or any orbiting spacecraft in a low Earth orbit.

Principal Investigator Microgravity Services (PIMS)

The PIMS group at NASA Glenn is responsible for processing, analyzing, and archiving the acceleration data measured by the two accelerometer systems previously described. During the STS–107 mission, acceleration data will be transmitted to the ground via telemetry links for real-time processing and analysis so that the scientists can assess the impact of the reduced-gravity environment in near real time on their experiments. Specialized displays are developed by the PIMS group to help the scientists make near real-time decisions in order to lessen the impact of the reduced-gravity environment on their science results, thereby maximizing good science data collection. PIMS will prepare an STS–107 mission microgravity characterization summary report which will highlight the reduced-gravity environment during the STS–107 mission to help the scientists take into account the adverse impact of the environment on their science results. PIMS will provide real-time support and post mission support to the Combustion Module-2 (CM–2) facility.

Specifications	TSH	FOG	CDU
Accelerometers:	Honeywell QA2000-30		
Resolution:	< 1 µg	0.1 Arc-sec.	
Weight:	1.1 lb	6 lb (2 boxes)	6 lbs
Power:	1.65 W	<10 W	30 W (entire system)
Interface:	RS–422	RS–232	Ethernet (external)

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For more information, visit the NASA Glenn Microgravity Science Division Acceleration Measurements Web Site at ***http://microgravity.grc.nasa.gov/MSD/MSD_htmls/acceleration.html***

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